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ABSTRACT

This report documents benefits and costs of restructuring two undergraduate courses at Virginia Polytechnic Institute and State University to better utilize instructional technology. Professors of the two courses, one in philosophy and one in microbiology, participated in workshops designed to help faculty explore the potential of electronic instructional technology and then restructured their courses to incorporate this technology. Learning outcomes from courses held in the spring of 1997 were evaluated. Students in the Web-based philosophy course section scored somewhat better than, or as well as, students in the traditional lecture section on 15 of 16 essay-scoring criteria. Learning outcomes from the microbiology course suggest no effect on grades of students taking the course, either before or after its redesign. Students in both restructured courses mentioned such advantages as better access to course materials. Institutional renewal through the instructional development initiative was also found. Analysis of costs (including the workshops, course conversions, and workstations for faculty and students) suggests that if 25 percent of a student's entire degree program were taken in these restructured courses, the cost per student would increase by $331 to $465. (DB)

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ED 423 802

Course Restructuring and the Instructional Development Initiative at Virginia Polytechnic Institute and State University: A Benefit Cost Study

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Course Restructuring and the Instructional Development Initiative at Virginia Polytechnic Institute and State University: A Benefit Cost Study

Virginia Tech
VIRGINIA POLYTECHNIC INSTITUTE AND STATE UNIVERSITY

Summary, Findings, and Conclusions

1. Virginia Polytechnic Institute and State University (Virginia Tech) is located on a 2,600-acre site in the town of Blacksburg in the southeastern part of the Commonwealth of Virginia. The university offers approximately 200 degree programs from the bachelor's through doctoral level to 25,000 students. Virginia Tech draws students from throughout the nation and the world. Approximately 73 percent are from the Commonwealth. Almost all students live on or adjacent to the campus.

2. As a way to focus upon the need for a university-wide strategy to leverage instructional technology to achieve its strategic mission, the Provost and the Vice President for Information Systems began in 1993 the implementation of an "Instructional Development Initiative." This large-scale effort was designed to invest in faculty (through a component program, the Faculty Development Initiative - FDI) by providing them an opportunity to rethink their teaching and explore the potential of (electronic) instructional technology for improving the effectiveness of the teaching-learning process.

3. Faculty who participated in the FDI workshops have been provided access to multimedia computers with high speed network connections. The campus has an ongoing program to equip classrooms and upgrade computer labs with sufficient computers to provide adequate access for students enrolling in the redesigned courses who do not have their own computers and network access.

4. Two professors who participated in the workshops restructured the courses that are the basis of this study: Philosophy 1204, Knowledge and Reality, taught by Dr. Valerie Hardcastle and Biology 2604, Introductory Microbiology, taught by Dr. G. William Claus. Data from these courses as taught in spring term 1997 are the primary basis for the evaluation of learning outcomes.

Learning Outcomes in the Philosophy Course

5. Dr. Hardcastle redesigned her course to simulate small group discussion sessions which were previously face-to-face. The redesign involved use of a combination of synchronous and asynchronous methods facilitated by emerging instructional technology applications. The redesigned course meets as a group only once per week for a regular lecture which primarily consists of an overview of the study topic for the week.

6. In the spring semester 1997, one section of the philosophy course was taught by Dr. Hardcastle in the "interactive web-based mode." The other section was taught by another faculty member in a more traditional large lecture/small discussion format.

7. Students in both sections of the course were assigned to write a persuasive essay. Forty essays were randomly selected from each section. These essays were scored and graded by three readers (graduate students in philosophy) from another university.

8. The evidence regarding learning outcomes is somewhat ambiguous. Students in the web-based course scored better than the lecture section on eight of sixteen specific essay scoring criteria deemed important to philosophical discourse, there was no significant difference between the two sections on seven of the criteria, and the lecture section scored significantly better on only one criterion. Based upon these results, the web-based section's performance on the essay was superior. This result is consistent with the increased writing and interaction regarding the writing that was built into the course redesign, i.e., that increased practice and review should improve performance. Even though the web-based group showed superior performance based upon the sixteen criteria, letter grades assigned by the readers to this particular essay showed no significant difference between the two groups.

9. In terms of responses to the student survey, there is evidence that student behavior was affected to the extent that over half had increased their use of the Internet and that over three-quarters better appreciated discussion, peer review and the value of informal writing as a component of the learning process (both of these results may indicate other learning outcomes that will be very important for students living in an increasingly digitized work and social environment). Less than a fourth of the student respondents felt there was too much use of the computer in the course.

10. Advantages most frequently mentioned by students in the web-based section were better access to course materials and convenience and flexibility in studying. The disadvantages most frequently mentioned were technical problems and the impersonal nature of the technology.

Learning Outcomes in the Microbiology Course

11. Biology 2604 is a sophomore level introductory microbiology course that enrolls approximately 200 students per semester. It is taught once each semester by Dr. G. William Claus who has been responsible for the course for several years. The class meets three times per week in a large lecture hall. There is an associated microbiology laboratory course, and, although it is not required, most students take the lab concurrently with the lecture course.

12. With the help of a grant from the Alfred P. Sloan Foundation, Dr. Claus and a development team in Virginia Tech's Educational Technologies Department restructured the course offering. The goals of the restructuring were to improve student access to course related materials and to improve communications between students and faculty and among students.

13. The changes took the form of enhancements to the lecture presentation, network access to all course materials, and new communications capabilities. All overhead transparencies were converted to PowerPoint slides which Dr. Claus used in lecture. These materials were in turn converted to files that students could access from the web site. An elaborate course web site was created that allowed students to access class announcements, frequently asked questions, course documents (e.g., syllabi), color slides, printable black and white slides, practice exams, live communication links to the professor and the teaching assistant (electronic office hours - "chat room"), direct e-mail to faculty, asynchronous discussions with other students ("message boards"), and links to other web sites related to biology and microbiology.

14. Although a statistical test for differences in learning outcomes based upon course grade comparisons over time was not performed, the evidence strongly suggests there is no difference in either mean grades or the grade distributions for versions of the course offered before and after the course redesign. The grades, themselves, provide no evidence that learning outcomes have changed as a result of the introduction of the network technology. (It is worth reiterating that Dr. Claus's objective in the course transformation was not to change the grades but to improve communications and increase student access to course materials.)

15. The student survey responses clearly indicate that the course web site has improved student access to course materials, which was one of the primary objectives of the course redesign.

16. The survey responses indicate, in terms both of activities and attitude changes, that students are learning to use the computer and the Internet as tools to assist them in their studies. Such results will have direct application in their careers after graduation.

Institutional Renewal

17. The Instructional Development Initiative is a large-scale effort to invest in the faculty of Virginia Tech by providing them with the opportunity to rethink their teaching and to explore the potential of instructional technology for improving the effectiveness of the teaching-learning process. This initiative is based upon the realization that digital technology is causing profound changes in the way people communicate with each other and gain access to various types of information. These changes have important implications for the curriculum both in terms of how the technology applies in particular disciplines and in terms of how courses can be taught. Students must be educated about these applications in order to function in society and the labor market.

18. Virginia Tech has met this responsibility with the Instructional Development Initiative and the Faculty Development Institute (FDI). The FDI provides both opportunities and incentives for the faculty, the campus's most valuable resource, to learn more about the application of the technology as it applies to their teaching activities and to work with each other in sharing ideas and experiences about the instructional applications.

19. This investment in human capital has been augmented by providing faculty with the appropriate desk-top computing equipment and network connections. It also includes a large-scale effort to provide network access, specialized computer labs, and support for students; classroom upgrades and equipment in classrooms to make them suitable for computer presentation and network access.

20. Many "graduates" of the FDI have continued to develop their courses and contribute to an exciting atmosphere that encourages change and innovation. Dr. Claus, in particular, attributes a renewal in his teaching to his experience in the FDI and subsequent support from the Department of Educational Technologies, which manages the FDI workshops.

Student Access

21. Virginia Tech's emphasis upon the use of the technology in the Instructional Development Initiative has been to improve communications and access to course materials for on-campus students. The Initiative is broadly conceived, however, and is providing the basis for an expansion of Virginia Tech's distance learning activities.

Costs

22. The costs of restructuring these courses include the one-time costs of the FDI workshops and the course conversions. Providing workstations for faculty and students is a major ongoing cost.

23. For courses that enroll 100-200 students per term, course costs, including FDI, course conversion, and workstations for faculty and students, the estimated costs are $4,200-$6,000. On a per student enrolled in one course basis the costs are $30-$42.

24. If 25 percent of a student's entire degree program were to be taken in these restructured courses, the cost per student would increase by $331-$465. If twenty-five percent of the university's courses were restructured, its annual expenditures on these activities would increase $1.7-$2.4 million.

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Background and Context

Virginia Polytechnic Institute and State University (Virginia Tech) was founded as a land grant college in 1872. The university occupies a 2,600-acre site in the town of Blacksburg, Virginia, in the southeastern part of the Commonwealth about 40 miles southeast of Roanoake. The University offers approximately 200 degree programs from the bachelor's through doctoral level to 25,000 students.

Virginia Tech draws students from throughout the nation and the world. Approximately 73 percent are from the Commonwealth. The student body is residential; almost all students live on or adjacent to the campus.

Blacksburg is a rural community with a population of 16,000 (not counting Virginia Tech's students). It is the site of the Blacksburg Electronic Village (BEV), a joint project of the community, Virginia Tech, and Bell Atlantic, to provide access to high speed communications throughout the community.

Even though it is a residential campus, leaders at Virginia Tech have a strong interest in distance learning. The institution has been offering distance learning programming for more than ten years. The Faculty Development Institute (FDI) includes a track on developing synchronous and asynchronous instructional delivery modes. It is clear that applications of digital electronic technology have the potential for changing delivery modes. There was also the need to ensure that students learn how the technology works and how to use it as it applies to their fields of study and to the evolving workplace environments.

The Instructional Development Initiative[1]

As a way to focus upon the need for a university-wide strategy to leverage instructional technology to achieve its strategic mission, the Provost and the Vice President for Information Systems began in 1993 the implementation of an "Instructional Development Initiative." This large scale effort was designed to invest in faculty by providing them an opportunity to rethink their teaching and explore the potential of (electronic) instructional technology for improving the effectiveness of the teaching-learning process. The Initiative led to the Faculty Development Institute which was designed to provide all 1,500 faculty at Virginia Tech an opportunity to participate over a four-year period in intensive summer workshops centered on the integration of instructional technology with the curriculum.

Responses to the workshops have been positive with the consequence that, in parallel, with the evolution of the technology itself, the content of the workshops has evolved from development of basic computer skills to much more sophisticated topics in the application of instructional design principles to course development activities and learning modules appropriate for specific disciplines. In addition to the summer workshops, a series of shorter workshops on various specific topics was conducted during the academic year. The interests of faculty have also shifted toward more emphasis upon producing materials that can be used by students enrolled in their courses. As part of the evolution of this strategy for leveraging instructional technology, twenty network-based courses were offered this summer to students from Virginia Tech who moved home to work over the summer.

[1] The following materials have been adapted from Virginia Tech, *Instructional Development Initiative*, August 1996.

Faculty who participated in the FDI workshops have been provided access to multimedia computers with high speed network connections. The campus has an ongoing program to equip classrooms and upgrade computer labs with sufficient computers to provide adequate access for students enrolling in the redesigned courses who do not have their own computers and network access. Virginia Tech has also been selected as a New Media Center, part of a national nonprofit corporation developed to assist campuses with the use of the new media in teaching and learning by means of a national network for disseminating information about the technology and its implementation in teaching. Virginia Tech has implemented a computer requirement for incoming freshmen for fall semester 1998. This was a faculty-driven initiative designed to ensure that all students had the appropriate resources to access course materials and Internet resources.

Benefit Estimates

Evaluations of Two Restructured Courses

Two professors who participated in the workshops restructured the courses that are the basis of this study: Philosophy 1204, Knowledge and Reality, taught by Dr. Valerie Hardcastle and Biology 2604, Introductory Microbiology, taught by Dr. G. William Claus. Data from these courses as taught in spring 1997 are the primary basis for the evaluation of learning outcomes.

Knowledge and Reality

Philosophy 1204 enrolls approximately 400 students per semester in two sections, which are ordinarily taught in large lecture halls. It is a freshman level course, but because it satisfies one of the university's core humanities requirements, it enrolls a range of students from freshman to senior level, very few of whom are philosophy or humanities majors. Table 1 provides demographic data on the 210 students enrolled in Dr. Hardcastle's section of the course. Although some attrition occurred during the early weeks of the class, students who dropped were replaced by an equal number of adds, resulting in a stable enrollment throughout the semester.

Table 1–Class Profile for Dr. Hardcastle's Section of Philosophy 1204

Class Level	Percent
Freshman	43.5%
Sophomore	36.7
Junior	10.8
Senior and Postbaccalaureate	8.8
Gender	
Male	58.5%
Female	41.5
Ethnicity	
Caucasian	87.0%
Asian	6.8
Latino	2.1
Other	4.1
Percent Owning Computer	83.8%

Course Redesign - The Interactive Web-based Section

As a result of significant budget cuts in the early 1990s, departments across campus were required to move to larger enrollment courses which were substituted for lower enrollment discussion sections. The Department of Philosophy is an example of this restructuring required by budget reductions.

Faced with the increase in class size, Dr. Valerie Hardcastle, a member of the philosophy faculty, redesigned her course to simulate small group discussion sessions which were previously face-to-face. Using a combination of synchronous and asynchronous methods facilitated by emerging instructional technology applications, she implemented a class web page that provides course news and related information, and has extensive interactive communication capabilities. As part of the Philosophy 1204 section, she requires students to engage in a variety of on-line discourse modes using both live chat sessions and asynchronous methods (e.g., a moderated version of a bulletin board). In addition to the assigned readings, several "workshops" on various topics in philosophy are offered each week. Students are required to participate in 14 of these workshops per semester.

Some of the discussion sections require on-line discussion and written responses to philosophical writings, movies and short stories. Responses can consist of live computer-mediated communication (using Daedalus software in a computer lab), synchronous chat sessions (over the web using NetForms software), asynchronous discussion postings (also web-based), homework assignments submitted over the web, and essays written and submitted in hard copy to the instructor. The redesigned course meets as a group only once per week for a regular lecture which primarily consists of an overview of the study topic for the week.

The primary difference in the designs of the new and old course involves what students do to fulfill their requirements. In the traditional approach, students read the text, attend class frequently and take extensive notes from the instructor's presentation, then write a few (2-3) long and polished papers during the semester. In the redesigned course, students also read the text, but they engage in much more writing (both informal and formal) in a variety of venues (i.e., on-line and asynchronous modes), receive more frequent challenges and critiques of their thoughts and assertions, and are required to describe, discuss and debate philosophical ideas from a variety of sources, e.g., movies, short stories, as well as philosophical texts. They receive much less of their information directly from the professor.

The Comparative Study

After teaching the class using these methods for several semesters, she did a comparative study of her students' writing with a section of the same class that was not using these teaching methods. The traditional class emphasizes finished papers written to be read and graded by a graduate teaching assistant while students in the web-based section wrote more frequently. Because much of the writing consists of interactive discourse, it is reviewed more frequently by peers, by the teaching assistants, and by the professor. In order to test the efficacy of this on-line interactive approach compared to the traditional lecture/discussion mode, Dr. Hardcastle designed a study to compare performance on an essay assignment written both by her students and by students in the traditional section.

In the spring semester 1997, one section of the course was taught by Dr. Hardcastle, in the "interactive web-based mode." The other section was taught by another faculty member in a more traditional large lecture/small discussion format. In the "traditional" section, the entire class meets twice per week for a regular lecture, and once per week in small discussion sections (35 students) led by graduate teaching assistants.

In the tenth week of the semester, students in both sections of the course were assigned to write a persuasive essay on the same topic. Forty essays were randomly selected from each section. These essays were scored and graded by three readers (graduate students in philosophy) from another university. Each reader read every essay. The readers did not know student names or the section in which the student was enrolled. The readers used a ten-point scale to rate each essay on 16 criteria all deemed important in terms of philosophical discourse (the criteria are listed in Table 2 below).

At a recent internal conference on instructional technology, Dr. Hardcastle summarized the point of the study in this way:

> I should stress that the reason we were looking at this [essay comparison], as opposed to some sort of content-based question or student evaluation is because the bread and butter in philosophy is whether students can write a successful, sharp, analytical paper. Everything else is icing. I don't really care whether they can remember two weeks after the course who Descartes was — my apologies to the historians of philosophy. I don't care if they can remember anything from the course as long as they can, when confronted with an issue, be able to articulate their views sharply and defend them with rational argumentation. (September 1997)

A multivariate analysis of variance was performed on the essay scores. It showed significant differences, and therefore a univariate analysis of variance (ANOVA) was conducted between all items. The results of that analysis are shown in Table 2.

There was no statistically significant difference between the two groups on seven criteria. The lecture section scored better than the web-based section on one criterion ($p < .05$), and the web-based section scored better than the lecture section on eight criteria (four criteria at $p < .10$ and four at $p < .05$). The web-based section appears to have outperformed the lecture section on the basis of the individual scoring criteria.

The readers were also asked to assign overall grades to the essays. The web-based section's average grade was slightly higher, a low "B" (mean grade = 4.74[2]) compared to a "B-" (mean grade = 5.03) for the traditional section. There was no significant difference ($p < .10$) between the mean essay grades for this particular essay for these two sections of the course. Even with what appears to be a superior performance based upon the criteria in Table 2, there was *not* a significant difference in the overall grades assigned to the essay.

[2] Calculated on a scale where A = 1 and D- (or less) = 10.

Table 2–Comparison of Essay Scores for Web-based and Lecture Sections of Philosophy 1204 - Spring Term 1997

Mean scores of the two sections were not statistically different (nsd at the p< 0.10 level)	Significance level
Scoring Criterion:	
This essay contains a thesis statement or conclusion.* (1)	nsd
The thesis or conclusion is clearly stated.* (2)	nsd
The reasons or arguments are relevant to the thesis or conclusion.** (4)	nsd
No reasons are anachronistic.* (6)	nsd
The reasons or arguments are cogent.** (7)	nsd
This essay's organization contributes to its readability.** (13)	nsd
This essay contains no extraneous material.* (15)	nsd
Mean scores of web-based sections were less than the score of the lecture section	**Significance level**
Scoring Criterion:	
This essay is succinctly written. (16)	p < .05
Mean scores of web-based sections were more than the score of the lecture section	**Significance level**
Scoring Criterion:	
No reasons or premises are missing. (5)	p < .10
This essay goes beyond simply stating the obvious. (9)	p < .10
The author of this essay understands the philosophical views described in the paper. (10)	p < .10
This essay's organization contributes to the force of the argument. (12)	p < .10
This essay contains reasons or arguments for supporting the thesis or conclusion. (3)	p < .05
This essay contains no factual errors. (8)	p < .05
This essay exhibits sensitivity to counter-arguments or counter-examples. (11)	p < .05
No errors in language or usage obscure the meaning of the sentences. (14)	p < .05

* The mean score of the web-based section was less than the mean score of the lecture section.

** The mean score of the web-based section was greater than the mean score of the lecture section.

Student Surveys

During the spring 1997 semester, a survey was administered to the students enrolled in Dr. Hardcastle's section of the course. The questions were concerned with the students' reaction to the technology, their opinions about its usefulness to success in the course, and their learning styles. Out of a course enrollment of 210, a total of 105 usable responses were obtained. The responses are summarized in Table 3. The responses were given on a 7-part Likert scale with 1 indicating a strong disagreement, 4 being neutral and 7 indicating strong agreement. In Table 3 responses 1 to 3 are aggregated as "disagree," 4 is neutral, and 5 to 7 are aggregated as "agree."

Table 3–Student Responses to Survey Statements (Web-based Section)

Statement	Disagree (%)	Neutral (%)	Agree(%)
1. "This class is increasing my knowledge and skills in computers."	39.0	28.6	32.4
2. "This course has increased my use of e-mail."	45.7	33.0	21.3
3. "This course has increased my use of the Internet."	22.1	25.0	52.9
4. "We have to use the computer **too much** in this class."	56.8	21.2	22.2
5. "Discussion is important to the learning process."	4.9	19.4	75.7
6. "I feel I have more interaction with my classmates in this class than in other classes."	35.6	22.1	42.3

The responses in Table 3, especially to items 1 and 2, must be interpreted in light of the fact that about 84 percent of the students own a computer (see Table 1). In spite of the high level of computer ownership, a majority of students indicated the course had increased their use of the Internet (item 3) and less than a fourth (somewhat more than the proportion who don't own computers) indicated that the computer was used too much in the class (item 4). Over 75 percent indicated that the discussion associated with the course was important to learning (item 5). In item 6, in spite of the fact that the entire class meets only once per week, instead of three times, a larger percentage (42.3) indicated they had more interaction with classmates than those who indicated they had less interaction (35.6).

In addition, Dr. Hardcastle administered an open-ended survey that asked students about the advantages and disadvantages of taking a "Cyber-course," a course that included an on-line, interactive component and required the use of a computer. The most frequently mentioned responses are shown in Table 4.

Table 4–Advantages and Disadvantages of a "Cyber-course"

Advantages	% of Students Who Mentioned
Better access to course materials	29.2%
Convenience/flexibility	17.4%
Improves interaction between teacher and student	15.3%
Disadvantages	**% of Students Who Mentioned**
Technical "glitches"	32.5%
Impersonal	29.0%
Lack of personal computers (access)	10.5%

Dr. Hardcastle is currently replicating the study using only data from sophomores in order to better control the level of study. In addition, she is beginning a longitudinal study to determine the existence of any long-term effects, advantages or disadvantages, associated with this type of course.

Conclusions Regarding Learning Outcomes in the Web-based Section of Philosophy 1204

- The evidence regarding learning outcomes is somewhat ambiguous. Students in the web-based course scored better than those in the lecture section on eight of sixteen specific essay scoring criteria deemed important to philosophical discourse, there was no significant difference between the two sections on seven of the criteria, and the lecture section scored significantly better on only one criterion. Based upon these results, the web-based section's performance on the essay was superior. This result is consistent with the increased writing and interaction regarding the writing that was built into the course redesign, i.e., that increased practice and review should improve performance. Even though the web-based group showed superior performance based upon the sixteen criteria, letter grades assigned by the readers to this particular essay showed no significant difference between the two groups.
- In terms of responses to the student survey, there is evidence that student behavior was affected to the extent that over half had increased their use of the Internet and that over three-quarters better appreciated discussion, peer review, and the value of informal writing as a component of the learning process (both of these results may indicate other learning outcomes that will be very important for students living in an increasingly digitized work and social environment). Less than a fourth of the student respondents felt there was too much use of the computer in the course.
- Advantages most frequently mentioned were better access to course materials and convenience and flexibility in studying. The disadvantages most frequently mentioned were technical problems and the impersonal nature of the technology.

Introductory Microbiology

Biology 2604 is a sophomore level introductory microbiology course that enrolls approximately 200 students per semester. It is taught once each semester by Dr. G. William Claus who has been responsible for the course for several years. The class meets three times per week in a large lecture hall. There is an associated microbiology laboratory course, and, although it is not required, most students take the lab concurrently with the lecture course.

Table 5 provides demographic data on the 185 students enrolled in microbiology in spring semester 1997.

Table 5–Class Profile for Microbiology Students Spring 1997

Class Level	Percent
Freshman	4.1%
Sophomore	48.6
Junior	31.1
Senior and Postbaccalaureate	16.2
Gender	
Male	42.5%
Female	57.5
Ethnicity	
Caucasian	89.6%
African-American	2.8
Asian	4.1
Latino	0.7
Native American	0.7
Other	2.1
Percent Owning Computer	73.6%

Course Transformation

With the help of a grant from the Alfred P. Sloan Foundation, Dr. Claus and a development team in Virginia Tech's Educational Technologies Department restructured the course offering. The course has been offered in this new format since spring semester 1996. The changes took the form of enhancements to the lecture presentation, network access to all course materials, and new communications capabilities. With design and technical support from the development team, all presentation materials (acetate overhead transparencies) were converted to digital format (color PowerPoint slides) which Dr. Claus used in lecture. These materials were in turn converted to files that students could access from the web site and

view or print out. An elaborate course web site was created that allowed students to access class announcements, frequently asked questions, course documents (e.g., syllabi), color slides, printable black and white slides, practice exams, live communication links to the professor and the teaching assistant (electronic office hours - "chat room"), direct e-mail to faculty, asynchronous discussions with other students ("message boards"), and links to other web sites related to biology and microbiology. In addition to the usual in-person contact, students were encouraged to contact Dr. Claus by e-mail and during the on-line electronic office hours.

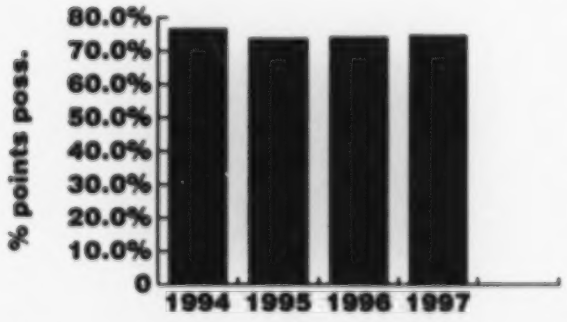
The Biology Department does not, as a general rule because of budget reductions, assign teaching assistants for their faculty who teach large, lower-level lecture classes. For this reason, biology faculty have a practice of evaluating students based upon machine-graded tests given two or three times per semester. This is in contrast to philosophy (and other high enrollment humanities and social science courses) which rely on more labor-intensive evaluation methods and therefore have three or four graders per course.

Learning Outcomes: Grades

Extensive grade data were available back to 1994, but it should be pointed out that Dr. Claus's goal was not so much to improve grades as it was (1) to improve student access to course materials and information and (2) to improve communication with faculty and among students. These course improvements probably do not influence grades so much as other factors, such as the changing qualifications of the student body, changes in student incentives, and changes in the examinations themselves.

There were no significant grade differences among the years. As illustrated in Chart I, the mean grade fell from a high of 76.6 in 1994 to a low of 73.6 in 1995, then rebounded slightly to 74.0 in 1996 and 74.5 in 1997.

Chart I–Grades by Year



The distribution of grades 1994-1997 for Dr. Claus's course is shown in Table 6. Since the new version of the course was first offered in spring 1996, the last two years of data represent the period after the change occurred. There are no consistent differences from year to year. (A more valid comparison of grades would have to control for the characteristics of the students enrolled and the continuous change in the content of the course and the exam questions.)

Table 6–Grade Distributions for Microbiology

Year	A (%)	B (%)	C (%)	D (%)	F (%)
1994	20.3	32.0	23.4	16.8	7.4
1995	15.0	29.9	26.0	17.4	11.7
1996	18.3	25.5	24.0	19.0	13.3
1997	16.8	29.7	27.0	15.7	10.8

Discussion: Grade Comparisons

There are several reasons why grade comparisons do not make a good basis for comparison:

(1) No standard tests are administered, either between sections taught by different faculty or between classes taught in different semesters by the same faculty. For example, Dr. Claus and others tend to change their tests and exams based on changes in teaching methods, the introduction of new content, identifying poorly worded questions, and many other factors, both conscious and unconscious.

(2) Many of the benefits from this type of course transformation are practical ones, such as ease of access to materials, and these types of benefits do not necessarily translate into increased learning as reflected in test scores. If microbiology students save time because they can access materials faster and "anytime, anywhere," they do not necessarily use that extra time to raise their grade in microbiology; they may, for example, use it to maintain their grade in another course that lacks such efficiencies and therefore requires more time, or for a host of other purposes (e.g., other activities, recreation, catching up on sleep, etc.).

(3) Test grades may not necessarily reflect the changes in the type of learning that students gain from the technological enhancement of instruction. For example, the microbiology course has improved graphics, which students can access at any time over the campus network. However, tests and exams — as in years past — are text-based and multiple choice. It could be questioned whether the limitations of these tests can reflect any increase in visual learning experienced by students.

On the other hand, Dr. Claus states that he has been very careful and consistent in the design and writing of his test items. Although he has been constrained by class size (and the general lack of a teaching assistant) to using machine-graded multiple-choice tests and exams, he works very hard to write test items that force students to think about the subject and engage in problem-solving that requires them to reason with the scientific concepts and factual information. Having taught some version of this course for almost 30 years, he has assembled a large bank of test questions that he has revised and refined over that period. Although this pool of questions undergoes constant revision, he is satisfied that the pool covers students' mastery of the material. He is relatively confident, therefore, that year-to-year grade comparisons have some validity.

Student Surveys

A series of surveys were administered to the microbiology class during spring 1997. Several of the questions sought student reactions to the technology and their opinions about its usefulness to their success in the course. Approximately 145 usable responses were obtained from the 185 students enrolled in the survey given in the eleventh week of classes. A summary of

responses to these survey questions is provided in Table 7. The responses were given on a Likert scale with 1 indicating strong disagreement, 4 being neutral, and 7 indicating strong agreement. In the table, responses 1 to 3 are aggregated as "disagree," 4 is neutral, and 5 to 7 are aggregated as "agree."

Table 7–Microbiology Student Responses to Survey Statements

Statement	% Disagree	% Neutral	% Agree
1. "The on-line course materials focus my attention on what to study."	15.3	9.5	74.5
2. "The use of technology in this class creates a friendly, open environment."	22.6	38.7	38.7
3. "Bringing the printed black and white slides to class is helpful [to learning]."	4.4	8.0	87.6
4. "Coming to class is **less important** in this course than my other courses because we have on-line materials."	54.4	18.4	27.1
5. "The on-line discussion questions help me think more about the class material."	30.0	21.9	48.1
6. "I enjoy answering and responding to the discussion questions."	59.8	17.5	22.7
7. "The discussion questions show me real-world applications of biology."	28.6	29.4	41.9
8. "On-line practice exams do **not** help me prepare for tests."	82.5	11.7	5.8
9. "A class web page is **not** a good way to communicate and give out information."	81.7	10.2	8.0
10. "Using the class web page saves me time."	22.0	22.6	55.5

Another indication of how students view the changes that have been made in the course structure—technological or otherwise—is to ask them about the usefulness of specific changes. Students were asked to respond to the following question: "Suppose a fellow student asked your advice about taking this course. Using a 1 to 7 scale (where 1 is not at all useful and 7 is extremely useful), rate the following items on their importance and usefulness for success in the class." The responses are summarized in Table 8 where responses 1 to 3 are aggregated to "not useful," 4 is neutral, and 5 to 7 are aggregated to "useful."

Table 8–Microbiology Student Responses to Survey Statements Regarding Usefulness

Statements Regarding Usefulness:	Not Useful (%)	Neutral (%)	Useful (%)
1. printing out or getting the slides *before* class	5.7%	5.8%	88.4%
2. printing and studying the black and white lecture slides	2.4	3.3	94.3
3. studying the full color lecture slides on the computer	66.2	15.3	18.6
4. attending the lecture	13.8	11.4	74.8
5. reading the textbook	28.2	19.4	52.5
6. the class chat room sessions	79.0	13.7	7.2
7. the practice exams	16.4	10.7	72.9
8. owning a computer with access to the network	17.9	12.1	67.7
9. e-mail access to the professor	30.7	29.0	40.4
10. the Explore Section of the course web page	72.6	13.7	13.7
11. taking the microbiology lab simultaneously with the microbiology lecture class	20.2	12.1	67.7

The responses to items 1 and 2 in Table 7 provide an important summary and in general are quite positive, but also illustrate the existence of some reservations about the on-line materials. Almost 75 percent of the respondents indicated the on-line materials helped them focus their study efforts but less than 40 percent felt the use of technology in this class added to the creation of a friendly open environment. Students liked access to the black and white slides before class and for study purposes (Table 7, item 3; Table 8, items 1 and 2). They also liked access to the practice exams (Table 7, item 8; Table 8, item 7).

The web site has become an integral part of the class structure. Over 81 percent of the students indicated that they thought the web page is a good way to communicate and give out information (Table 7, item 9). To this point, however, students indicate only a modest interest in using e-mail to communicate with the professor (Table 8, item 9). Similarly they tended not to use the site for real-time communication. For example, Dr. Claus instituted "electronic office hours," when he or a teaching assistant were on-line in "chat" mode for

1 hour per day, 5 days per week, but few students contacted the faculty while they were on-line. Interviews with students revealed, however, that many read others' comments from the chat rooms and sometimes submitted queries to that page throughout the week, thus using it in an asynchronous mode.

Dr. Claus also incorporated on-line discussion questions for grade credit. Students read and responded to broad-based, subject-related questions; after posting their response, they read the responses of other students in their chat group and then resubmitted their responses. Submissions were graded by undergraduate assistants. Student response to the discussion questions was somewhat less than enthusiastic, 23 percent indicated they enjoyed the discussion questions (Table 7, item 5), the chat room sessions were rated not useful by 79 percent of the students (Table 8, item 6). However, 48 percent did admit the questions helped them to think more about the class material and 42 percent indicated the questions showed them real world applications of biology (Table 7, items 5 and 7).

Finally, it is worth noting that over 55 percent of the students indicated that the web page saved them time.

The changes in microbiology were not initially intended to convert it to a distance learning environment. It was critical for the students to attend lectures because the online materials in the early version of the course contained only the presentation slides used in the lectures. (Students realize this—nearly 75 percent indicated that attending the lecture was useful for success in the course, see Table 8, item 4.) Subsequently, Dr. Claus has created a totally on-line version that is used by both distant and local students.

Nevertheless, ready access to class materials and information outside of class was one of Dr. Claus's primary goals in transforming the course. Even on a resident campus, such as Virginia Tech, it can be frustrating for students to trek across campus and wait in line at a professor's office to ask a single question, to wait at the library during peak times to get access to reserve materials or practice tests, and most of all, to get notes for a lecture they missed. Similarly, faculty waste valuable time by answering the same question endless times and they are frustrated when they must get important information out to hundreds of students on short notice. Based upon the responses to items 9 and 10 in Table 7, students substantially agree that the web site has worked for these purposes.

An additional indicator of the usefulness of the class web site is how frequently students access it. Table 9 shows student survey responses regarding how often they used specific parts of the web site.

Table 9–Student Responses Regarding Use of the Web Site

Part of Web Site Accessed	Never or Only Once (%)	Couple times a semester, but no more than every other week (%)	One or more times per week (%)	One or more times per day (%)
Class News Page	0.8%	8.8%	64.5%	25.9%
Full color class lecture slides	73.2	21.2	5.7	
Printable black and white slides	6.5	45.2	46.8	1.6
Explore Page	69.4	29.0	1.6	

Note the disparity in frequency with which students access different parts of the web site. When a part of the web site is perceived as useful, it is used heavily; if not, it is virtually ignored. For example, the news and announcements page communicated a change of test location or time, correction of errors in the slides, and other items of immediate interest. Furthermore, Dr. Claus estimated that he recovered from 5 to 10 minutes (10-20 percent) of each 50-minute class period for teaching purposes by using the news page instead of making announcements in class. He also was confident that he had reached everyone, including late arrivals and non-attendees. Likewise, the printable slides allowed students to print up-to-date class notes ahead of class, and then listen to the lecture instead of transcribe notes from the screen. In interviews with students, the capability to get notes before class was invariably mentioned as the greatest advantage of this technology.

On the other hand, the color version of these slides was perceived as superfluous. In interviews, students indicated these slides were slow to download and could only be viewed on the computer (hard copies required access to a color printer). Similarly, few students accessed the Explore page, because no assignments were tied directly to it (extensive use of the Explore page would have required a substantial time commitment for students to go beyond the basic requirements of the course). Although it is not reported in the table, practice exams were also available at the web site and were heavily used before examinations.

Changes in Student Attitudes

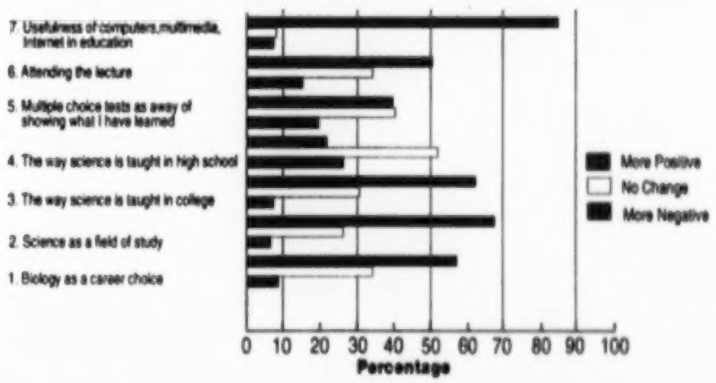
In the fourth survey of the semester students were asked: "As a result of taking this course, please indicate how your attitude has changed toward the topics listed. Responses were provided on a seven-part scale where 1 was most negative, 4 was neutral, and 7 was most positive. In Table 10 responses 1 to 3 are aggregated as "more negative," 5 to 7 as "more positive."

Table 10–Changes in Student Attitudes After Taking the Microbiology Course

Topic	More Negative	No Change	More Positive
1. Biology as a career choice	8.7%	34.3%	56.9%
2. Science as a field of study	6.6	26.3	67.2
3. The way science is taught in college	7.4	30.7	62.1
4. The way science is taught in high school	26.3	51.8	21.8
5. Multiple choice tests as a way of showing what I've learned	19.6	40.4	39.7
6. Attending the lecture	15.3	34.3	50.3
7. Usefulness of technology in higher education (i.e., computers, multimedia, Internet)	7.4	8.1	84.5

The data in Table 10 and Chart II provide a clear indication that student attitudes underwent a positive change during the semester. For items 1 through 6 it is difficult to determine whether the changes should be attributed to the learning process in general, to the introduction of the computer technology, to the course restructuring, to the instructor's personality, or to other factors. The students felt that the course had a positive influence on their choice of biology as a career field, on science as a field of study, and the way science is taught in college (as opposed to high school). The importance of such a boost in motivation cannot be underestimated during the crucial sophomore and junior years, when many students tend to drop out of the sciences. It is also encouraging that, despite the class size and the required use of multiple-choice tests, students seemed to be more positively than negatively disposed toward Dr. Claus's creative use of thought-provoking questions on his tests and to the lecture mode of delivery.

Chart II–Changes in Student Attitudes After Taking the Microbiology Course


7. Usefulness of computers,multimedia, Internet in education
6. Attending the lecture
5. Multiple choice tests as away of showing what I have learned
4. The way science is taught in high school
3. The way science is taught in college
2. Science as a field of study
1. Biology as a career choice
More Positive
No Change
More Negative
0 10 20 30 40 50 60 70 80 90 100
Percentage

The response to item 7 does provide good support for the usefulness of electronic media in higher education. Almost 85 percent of the respondents indicated that their attitude had become more positive toward such use of computer technology as a consequence of having taken the course. Such a result suggests strongly the students found the technology to be truly useful to them in their studies.

Conclusions About Learning Outcomes in Microbiology

- Although a statistical test for differences in learning outcomes based upon course grade comparisons over time was not performed, the evidence strongly suggests there is no difference in either mean grades or the grade distributions for versions of the course offered before and after the course redesign. The grades themselves provide no evidence that learning outcomes have changed as a result of the introduction of the network technology. (It is worth reiterating that Dr. Claus's objective in the course transformation was not to change the grades but to improve communications and increase student access to course materials.)
- The student survey responses clearly indicate that the course web site has improved student access to course materials, which was one of the primary objectives of the course redesign.
- The survey responses indicate, in terms both of activities and attitude changes, that students are learning to use the computer and the Internet as tools to assist them in their studies. Such results will have direct application in their careers after graduation.

Institutional Renewal

The Instructional Development Initiative is a large-scale effort to invest in the faculty of Virginia Tech by providing them with the opportunity to rethink their teaching and to explore the potential of instructional technology for improving the effectiveness of the teaching-learning process. This initiative originated jointly from the Office of the Provost and the Office of the Vice President for Information Systems. It is based upon the realization that digital technology is causing profound changes in the way people communicate with each other and gain access to various types of information. These changes have important implications for the curriculum both in terms of how the technology applies in particular disciplines and in terms of how courses can be taught. Students must be educated about these applications in order to function in society and the labor market.

Virginia Tech has met this responsibility with the Instructional Development Initiative and the Faculty Development Institute (FDI). The FDI provides both opportunities and incentives for the faculty, the campus's most valuable resource, to learn more about the application of the technology as it applies to their teaching activities and to work with each other in sharing ideas and experiences about the instructional applications.

This investment in human capital has been augmented by providing faculty appropriate desk-top computing equipment and network connections. It also includes a large-scale effort to provide network access, specialized computer labs, and support for students; classroom upgrades and equipment in classrooms are provided to make them suitable for computer presentation and network access. The FDI began with three pilot faculty workshops during the summer of 1993, and has continued with an increasing schedule of workshops since May 1994. By July 1997, over 1,400 faculty (out of approximately 1,500) from all academic departments had participated in customized 3- and 4-day workshops that cover topics ranging from computer basics and e-mail to multimedia course design and development and using the World Wide Web as an instructional

medium. As part of the initiative, each participating faculty member is furnished with a high-end computer, a full suite of software and an office Ethernet connection.

Many "graduates" of the FDI (including Drs. Claus and Hardcastle) have continued to develop their courses and contribute to an exciting atmosphere that encourages change and innovation. Dr. Claus, in particular, attributes a renewal in his teaching to his experience in the FDI and subsequent support from the Department of Educational Technologies, which manages the FDI workshops.

The two courses reviewed above provide specific evidence of how the institutional renewal efforts of the campus are affecting the instructional process and improving students' understanding of the use of computers.

Student Access

As a primarily residential campus, Virginia Tech's emphasis upon the use of the technology in the Instructional Development Initiative has been to improve convenience and access to course materials for on-campus students rather than attempt to improve access for place-bound and relatively distant suburban and urban populations. The initiative is broadly conceived, however, and is providing the basis for an expansion of Virginia Tech's distance learning activities.

Such improvements may be important for classroom instruction. Professor Claus estimates a 10-20 percent saving in class time by reducing the need for announcements and course management issues in class. If this time is redirected toward more instructional content, the efficiency of the instructional process is substantially improved. Similarly, to the extent students can obtain class information, class assignments, and access to information resources generally more efficiently over a network, they experience time savings that can also be redirected to more study.

Cost Estimates

The component costs associated with redesigning and restructuring the courses include costs related to the Instructional Development Initiative and the Faculty Development Institute. Some of the costs are one-time and some are continuing. Table 11 provides the basis for cost estimates related to faculty who participate in the FDI and who then convert one or more of their courses. The estimates are dependent upon a series of assumptions that are spelled out in the table. The one-time costs of course conversion are amortized over a five-year period. Once the courses are converted, it is assumed faculty will maintain them. The estimate of $2,340 cost per course per term is based upon a conversion funded by Virginia Tech's Instructional Services unit. Many faculty, including Dr. Hardcastle, have converted courses without special funding to do so.

Table 11–Estimated Faculty and Course Conversion Related Costs Philosophy and Biology

Item	Amount	$/Course
FDI cost	$2,000/faculty	
if two courses are converted...	$1,000/course	
if cost is amortized over...	5 years	$200/course/year
Faculty workstation costs	$2,500/station*	
if useful life is...	4 years	
annual station cost...	$625/station/year	
if annual maintenance cost is...	$94/station/year**	
total workstation cost is...	$719/year	
number of courses are converted...	2 courses	$360/course/year
Course conversion costs* **		
Assistance from Educational Technologies...	$16,500	
Faculty stipend...	$5,000	
Total conversion cost...	$21,500	
if cost is amortized over...	5 years	$4,300/course/year
Estimated costs per course		$4,860/course/year
		$2,430/course/term

* Includes software.
** Calculated at 15 percent of station cost.
***Source: Virginia Tech, "Access" report, July 1997, pp. 15-17.

The Instructional Development Initiative also includes computer access for students enrolled in the restructured courses. Estimates of the costs of providing this access are shown in Table 12 along with the various assumptions that are necessary in order to convert workstation costs to costs per enrollee in a converted course.

Table 12–Estimated Costs of Providing Computer Access for Students

Item	Amount	$/Enrollee/ Course
Cost of student workstation	$2,500	
if useful life is...	4 years	
annual station cost...	$625/year	
annual maintenance cost...	$94/year	
Total workstation cost...	$719/year	
If stations are available...	50 hours/wk	
and student workload/course/week is...	5 hrs/course/week	
one campus station accommodates the coursework of...	10 enrollees/term or 20/year	
If half of the workload* is accomplished on student owned equipment, one campus workstation accommodates the equivalent coursework of ...	20 enrollees/term or 40 per year	
Workstation cost per enrollee per course		$17.98

* This is a conservative estimate based upon the data presented in Tables 1 and 5 to the effect that over 70 percent of the students enrolled own computers. Student computer owners, however, may still make some use of campus computers. (Virginia Tech has just instituted a requirement that all entering freshmen own a computer with specified capabilities, including a network connection.)

Table 13 combines the cost estimates from Tables 11 and 12 to show total restructuring costs on a per course and a per course enrollee basis. Consistent with the initial emphasis of the Instructional Development Initiative to convert courses that enrolled large numbers of students, the costs are calculated on the basis of 100 and 200 enrollments per course section.

Table 13–Estimated Course Restructuring Costs for Alternative Course Enrollments

Section Enrollments	100	200
Estimated course related costs (from Table 11)	$2,430	$2,430
Estimated student workstation costs (@ $17.98 from Table 12)	$1,798	$3,596
Total restructuring costs per course offering	$4,228	$6,026
Total restructuring costs per course enrollee	$42.28	$30.13

In summary, the estimated costs of the restructured courses ranges between $4,200 and $6,000 per course section for the larger enrollment courses. This converts to between $30 and $42 per student enrollee.

To put some perspective on these latter numbers, assume a student accumulates 132 units to graduate (44 three-unit courses). If 25 percent of these courses (11) were taken in the restructured format, the additional costs on a per graduating student basis would be in the range of $331 to $465. Alternatively, if the 25,000 students at Virginia Tech take, on average, 9 courses per year, total course enrollments are 225,000. If 25 percent of these enrollments (56,250) were in restructured course sections, estimated annual cost to the campus (including amortized costs) would be in the range of $1.7 to $2.4 million.